Daily topics and homework assignments

Classical Mechanics and Electromagnetism in Accelerator Physics

January 25 — February 5, 2016

version 24 January 2016

Schedule: Morning lectures 9am-12pm. Afternoon, 2pm-4pm, combination of demonstration problems and either new topics or reinforcing previous lectures. Solutions to previous homeworks can be gone over in detail during the afternoon, please ask. Will be available for questions after dinner, either in the classroom or ballroom D.

Course materials are available at `http://laser.lbl.gov/~gpenn/uspas2016`

Each homework problem will be worth the same number of points.

Note: Assigned homework problems (except for the first Monday and Tuesday) are subject to be changed, possibly at the end of the previous day's morning lecture. Demonstration problems, to be worked out in front of the class, are also subject to change.

First week: mostly classical mechanics

Monday (Jan 25)

Morning lecture: lectures 2 and 3 from notes: oscillators, Lagrangian and Hamiltonian.

Afternoon topics: Poisson brackets; pendulum equation, RF buckets with acceleration.

Demonstration problems: 2.6, 2.7, 3.3

Assigned hw: 2.1, 2.2 (assume $\gamma = 0$), 2.5, 3.1, 3.2, 3.4

Tuesday (Jan 26)

Morning lecture: lectures 4 and 5 from notes: canonical transformations, Liouville theorem, action-angle coordinates; generating functions (focus on 2nd type); motion as canonical transformation; extended canonical transformations (extra handout), may delay.

Afternoon topics: examples of generating functions

Demonstration problems: 3.6, 4.1, 5.2

Assigned hw: 3.8, 4.2, 4.6, 5.3, A1, A2

Wednesday (Jan 27)

Morning lecture: lectures 6, 7, 8 from notes: circular accelerator and corresponding equations of motion; Hills equations, beta functions.

Afternoon topics: more on beta functions. Define $\gamma = (1 + \alpha^2)/\beta$, derive $d\gamma/ds = -K(s)d\beta/ds$.

Demonstration problems: 6.3, 7.1, 7.4, 7.5, 7.6

Assigned hw: 6.5, 7.2, 7.7, 8.3, A3

Thursday (Jan 28)

Morning lecture: lectures 9, 10 from notes: field errors, resonances, dynamic aperture (no nonlinear resonances), standard map. Possible catch-up day.

Afternoon topics: Show simulations of standard map (using matlab live, or just plots). Maybe discuss unstable motion and feedback.

Demonstration problems: 9.4; some beta function calculations

Assigned hw: 9.1 but do not calculate hamiltonian, 9.6, 10.1, 10.2, A4

Friday (Jan 29)

Morning lecture: lectures 11, 13: kinetic equation, Vlasov equation, special relativity, Lorentz boost; retarded time. Focus on how physical dimensions transform. Also conservation of photon number. Fluid equations from supplement, may move to afternoon.

Afternoon topics: calculating rest frame beam properties; a specific change in energy, as viewed in different reference frames; maybe some examples of Lorentz transform of properties from handout, such as volume, momentum, velocity, frequency and wavelength.

Demonstration problems: 11.2, 13.1, 13.7

Assigned hw: 11.1 (use Hamiltonian from Eq 7.15 in the notes), 11.3, 13.3, 13.4, 13.5, 13.9

Second week: E&M but still some focus on mechanics

Monday (Feb 1)

Morning lecture: lectures 14, 15, 16.1-4: electrostatics, self-fields of beams, a little about boundaries; Transition radiation? Total self-field energy from a Gaussian bunch, this would be coherent transition radiation.

Afternoon topics: image charges; more on relativity? Retarded time if not covered yet.

Demonstration problems: 15.2, 15.4; image charge examples

Assigned hw: 14.1, 15.3, 15.5, 15.6, 16.1, 16.2

Tuesday (Feb 2)

Morning lectures: lectures 17, 25.1-2, 18 from notes, eikonal equations from supplement: wave equation, eikonal formalism, waveguides, retarded potentials

Afternoon topics: Panofsky-Wenzel theorem; radiation reaction and total power emitted by a non-relativistic moving charge (simplified). Recent work on making classical wave equation look like the Schroedinger equation.

Demonstration problems: 25.1, 17.1, 18.2 with hint, 18.3

Assigned hw: 17.4, 17.5, 17.6, 18.2, 25.2 (p.199), 25.4 (p.203)

Wednesday (Feb 3)

Morning lectures: lectures 20, 24, 12: synchrotron radiation, synchrotron damping, quantum heating

Afternoon topics: synchrotron damping and heating, dynamics and equilibrium; damping ring design? No details on coupling, but mention condition on sum of decay times for degrees of freedom (based on correction to Louiville thm).

Demonstration problems: 20.3, 24.1, 24.2

Assigned hw: 20.1, 20.2, 20.3 (no plot), 20.4, 24.1, 24.2 [the problem should read $E_s(s \to 0)$]

Thursday (Feb 4)

Morning lecture: take a few bits of lectures 19, 23; very simplified CSR; formation length and coherence. Lecture 22, transition radiation, discuss beam diagnostics if time permits.

Afternoon topics: review for exam.

Demonstration problems: 19.1, 19.5, 22.1, 22.2; problems on earlier topics for review.

Assigned hw: none

Friday (Feb 5)

Exam, 9am-12pm.